Conflicts of interest

None.

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Effects of 16-week Tai Chi intervention on postural stability and proprioception of knee and ankle in older people

Sir—A decline in proprioception with ageing has been found to be associated with an increased propensity in elderly individuals to fall [1]. As a traditional Chinese exercise, Tai Chi (TC) has demonstrated its beneficial effects on health, particularly on the maintenance of balance control in older people [2]. Among the factors that relate to balance control, studies have demonstrated the beneficial effects of TC on muscle strength and fitness; the impacts of TC on proprioception has not been well documented [3, 4]. To more clearly understand the benefits of TC on postural stability, information about the impacts of regular TC exercise on proprioception is needed. Hence we designed the present study to examine the effects of a 16-week TC training programme on postural stability and proprioceptive function in elderly subjects.

Methods

Participants

Community-dwelling adults without previous TC experience, aged 60 years or older, were recruited through questionnaire administration and follow-up interviews. Subjects were not included in this investigation if they reported any of the following conditions: falls and/or dizziness in the last 6 months, neurological diseases which impaired mobility, dementia, cardiovascular disease which is symptomatic during moderate exercise, poorly controlled hypertension, and use of specific medications which are known to impair balance. A total of 50 elderly people, who regularly participate in social and


doi:10.1093/ageing/afn111
Published electronically 16 May 2008

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recreational activities outside their home on a minimum of two occasions per week, participated in this project. The subjects were randomly divided into two groups: the TC intervention group (25) and the control group (25).

An informed consent form was given to each subject prior to participation. This study was approved by the local medical ethics committee.

TC intervention

The subjects in the TC group participated in a 16-week TC training programme. TC training was organised and monitored by one qualified TC instructor. In the first 6 weeks, the subjects were taught with 24-form TC for at least four sessions per week, with each session lasting 60 min.

The subjects in the sedentary control group were instructed not to change their exercise levels throughout the study. They met weekly for an hour with the researchers to discuss topics of interest to older people.

Testing protocol and outcomes

(See Appendix 1 in the supplementary data on the journal’s website) Tests were conducted among the participants before and after the 16-week intervention. Kinaesthesia of the knee and ankle joints was examined using a custom-made device [5]. The postural stability was assessed by time stance tests in three postures: single-leg stance with the eyes open (SLO), single-leg stance with the eyes closed (SLC), and tandem stance with the eyes closed (TSC).

Statistics

The differences in baseline data were analysed by unpaired t-tests. Analysis of variance (ANOVA) with repeated measurements was used to determine the effects of different groups, different time durations (pre- and post-intervention), and the interaction of these two variables on the measurements. When ANOVA analysis revealed significant time and time-by-group interaction effects, paired t-tests were used to compare the changes in measures within groups; one way analysis of covariance (ANCOVA) was used to compare the differences between groups at the post-test, with the pre-test scores as covariates. The significance level was set at 0.05.

Results

Baseline characteristics of the subjects

No statistical differences in the baseline values were found between the groups (Table 1). Of the 50 subjects who started the study, 40 completed the post-test (90%). The final number of participants was 22 for TC and 18 for the control group. The dropouts did not appear to significantly affect the groups on any of the outcomes or demographic measures at the baseline measurement.

Compliance with the TC interventions was assessed by the number of exercise sessions attended, divided by the number of sessions held. The mean participation rate was 92%, which ranged from 80 to 100%.

Proprioceptive function

Knee motion sense in flexion and extension was improved by 36 and 25%, respectively, from the baseline in the TC exercisers, while it was 14 and 5%, respectively, in the control group (Table 1). Adjusting the baseline scores, the TC group had a significantly smaller mean threshold for the detection of passive motion in flexion and extension than the control group \((P = 0.046 \text{ for flexion, } P = 0.016 \text{ for extension}).

There were no significant differences in the motion sense between plantar flexion and dorsiflexion, thus the data from two directions were averaged to derive the ankle kinaesthesia. The TC exercisers could detect a significantly smaller amount of motion in ankle at the post-test than at the pre-test \((P = 0.004).\) However, there was no significant time-by-group interaction, indicating that the training effect of TC exercise on ankle kinaesthesia was not obvious.

Postural stability

TC exercisers improved by 47 and 91% from the baseline in their SLO and SLC stance time respectively, which was statistically significant \((P = 0.00)\). The control-group subjects did not significantly change their performance in SLO \((P = 0.761).\) ANCOVA, on the post-test scores, with the pre-test scores as covariate, revealed a significant difference between the two groups in SLO-stance time only \((P = 0.034).\) Both TC and control group showed a tendency towards increasing their stance time in TSC test (improving by 42.8% in the TC group, and 12.2% in the control group). However, there were no significant time effect and time-by-group interactions.

Discussion

Effects of TC on proprioception function

To date, only one published paper by Jacobson et al. assessed the effects of TC on proprioceptive function [6]. The study compared a group of adults (20–45 years of age) who participated in a 12-week TC practice with another age-matched control group. The authors measured the position sense of glenohumeral medial rotation at 30°, 45°, and 60°. The TC group significantly exhibited greater accuracy in position sense only at 60° glenohumeral rotation than the control group. The authors explained that this improvement is related to TC movement characteristics. The TC forms practised predominantly required glenohumeral rotation and positioning closer to the greater angle tested, 60°.

TC involves a series of smooth, graceful movements. The specificity of movements dictates replicating very specific joint angles in the limbs. At the end of the 16-week TC practice, almost all subjects could individually perform all the movements of 24-form TC, but we noticed that their performances were not well coordinated, especially in foot movements, such as deliberate movement of the toe up or down, or turning of the feet to the left or to the right. This might partly explain why no significant improvement was found for ankle kinaesthesia. By comparison, the motion
Table 1. Demographics and performance on measures at pre- and post-intervention of TC and control groups (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>TC intervention group</th>
<th>Control group</th>
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<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
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<td></td>
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<td></td>
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<tr>
<td>Demographics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female/male</td>
<td>12/13</td>
<td>11/11</td>
</tr>
<tr>
<td>Age (years)</td>
<td>64.9 (3.2)</td>
<td>65.2 (2.9)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.1 (7.9)</td>
<td>162.7 (6.9)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.5 (10.8)</td>
<td>66.7 (9.5)</td>
</tr>
<tr>
<td>Kinaesthesia (◦)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle</td>
<td>2.01 (0.68)</td>
<td>1.59 (0.45)</td>
</tr>
<tr>
<td>Knee-flexion</td>
<td>1.54 (0.72)</td>
<td>0.99 (0.36)</td>
</tr>
<tr>
<td>Knee-extension</td>
<td>1.77 (0.65)</td>
<td>1.32 (0.33)</td>
</tr>
<tr>
<td>Stance time (s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLO</td>
<td>34.11 (18.26)</td>
<td>50.27 (15.59)</td>
</tr>
<tr>
<td>SLC</td>
<td>3.35 (2.82)</td>
<td>6.42 (4.59)</td>
</tr>
<tr>
<td>TSC</td>
<td>30.50 (20.92)</td>
<td>43.54 (21.87)</td>
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SLO, SLC, single stance with eyes open and closed; TSC, tandem stance with eyes closed.

of the knee joint was mastered more easily. Almost all TC movements are performed in a semi-squatting posture, which puts more stress on the knee joint and gives a great range of motion to control the height of centre of gravity during the smooth and slow movement [7]. Therefore, knee kinaesthesia was found to be more sensitive to TC training than ankle kinaesthesia in this study. A cross-sectional designed study had found that long-term TC exercisers with more than 4 years experience showed significantly better proprioception of the ankle joint compared with the long-term regular joggers/swimmers, and sedentary elderly people [5]. Therefore, to improve proprioception of the ankle joint, the 16-week TC intervention might not be longer enough.

**Effects of TC on postural stability**

Improved balance in old people is widely accepted as one of the most common benefits of TC practice. In the present study, the TC group showed significant improvement in SLO stance time, but this change was not presented in the balance tests with eyes closed (SCL, TSC). The results were consistent with those by Schaller [8], but not Hong et al. [9] who reported that long-term TC practitioners (at least 10 years) showed significantly better postural stability without vision aid as compared with age-matched non-practitioners. Lord et al. (1991) demonstrated that the proprioception sensation is the most important sensory system in the maintenance of static postural stability in the elderly people [10]. A cross-sectional study [11] found that reduced ankle kinaesthesia and knee extensor strength were particularly associated with poor stability in TSC. In the present study, the significant training effects of the 16-week TC intervention in knee proprioception, but not in ankle, might be one of the reasons that postural stability with eyes closed was not improved. Therefore, it is recommended that older people should engage in long-term, regular TC exercise to help them gain more health benefits in proprioception.

**Conclusion**

The 16-week TC intervention conducted in this study provides evidence on TC’s benefits among older people. The significant improvements in postural stability with vision aid and the proprioception of the knee were found. The improvement in postural stability without vision help and proprioception of the ankle by TC intervention could not reach the significant level. This may be due to the limited intervention period. Therefore, future studies may verify these results with a longer period for TC intervention.

**Key points**

- A decline in proprioception with ageing has been found to be associated with decreased postural stability and increased propensity to fall among elderly individuals.
- This study examined the effects of a 16-week TC training regimen on postural stability and proprioceptive function of knee and ankle among the elderly.
- The 16-week TC training regimen significantly improved postural stability with the aid of vision, but not without the aid of vision. TC training significantly benefits proprioception of the knee. Proprioception of the ankle was also improved by TC training, but not to a significant level.

**Conflicts of interest**

None.

**Supplementary data**

Supplementary data for this article are available at *Age and Ageing* online.
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doi:10.1093/ageing/afn109
Published electronically 9 June 2008

Central and peripheral autonomic integrity
in Parkinson’s disease

SIR — Parkinson’s disease (PD), pure autonomic failure
(PAF) and multiple-system atrophy (MSA) are strongly
associated with primary autonomic failure (AF). Orthostatic
hypotension (OH) is the hallmark of sympathetic neurocircu-
lar failure accompanying these conditions.

Sympathetic neurocirculatory failure in PAF and MSA is
due to lesions in the peripheral (post-ganglionic sympathetic
neurons) and central autonomic pathways (olivopontocerebral
system, brain stem nuclei and pre-ganglionic neurons), respec-
tively. Increase in arginine vasopressin (AVP) following a head-up tilt (HUT) confirms the
presence of central autonomic integrity [1]. Normal basal
nor-adrenaline (NA), and an increase in NA following
HUT confirms the integrity of peripheral autonomic
pathway [2, 3]. Therefore patients with MSA fail to increase
AVP following HUT, whereas patients with PAF have low
basal NA, and fail to increase NA following HUT. It has
been suggested that the mechanism of OH in PD is similar
to that of PAF [4].

However, the mechanism of sympathetic neurocirculatory
failure in PD is unclear and we hypothesise that it is due
to the lesions in both central and peripheral autonomic
pathways, because Lewy bodies (LB), which are a marker of
neurodegeneration have been demonstrated in both central
and peripheral autonomic pathways [5, 6]. In this study, we
assessed the autonomic integrity in patients with PD to
establish the site of lesion in sympathetic neurocirculatory
failure.

Methods

We identified patients with PD from the movement disorder
clinic register, all of whom fulfilled the UK Brain Bank
diagnostic criteria. We excluded subjects with any medical
condition or current drug therapy (except medications for
PD) that would affect their autonomic function based on
medical review and assessment. Also, patients with significant
cognitive impairment were excluded. We identified an age
and sex-matched healthy controls free from any known
diseases and not on any drugs from a general practitioner’s
list.

Protocol

We carried out the study in the morning and did the
following assessments: blood pressure (BP) in the supine
position, blood samples for estimation of basal NA and
AVP, continuous ECG monitoring, BP every minute using
an automated BP monitor, and used the tilt table to perform
HUT to 60° for 10 min. At the end of this we took blood
samples for estimation of NA and AVP. Samples were stored
and analysed as a single batch using high-performance liquid
chromatography to avoid interbatch variations.

Following these assessments, we did a battery of card-
violecular autonomic tests including BP response to
handgrip manoeuvre and heart rate response to valsalva
manoeuvre. We assessed the severity of PD [using full
Unified Parkinson’s Disease Rating Scale (UPDRS)], cognitive
function [Mini-Mental Status Examination (MMSE)], depress-
symptomatology [GDS-15 Geriatric Depression Scale
(GDS)] and autonomic symptoms [Autonomic Symptoms
Scale (ASS) [7]]. We defined OH as a fall in systolic
pressure of 20 mm Hg or diastolic BP of 10 mmHg within 3 min.